PRECISE EFFICACY ASSAY METHODS
FOR ACTIVE AGENTS INCLUDING CHEMOTHERAPEUTIC AGENTS

Related Application

This is a Continuation-In-Part of U.S.
Application Serial No. 08/679,056, filed July 12, 1996.

Field of the Invention

The invention relates to screening and testing of
active agents, including chemotherapeutic agents, to
predict potential efficacy in individual patients in whom
treatment with such agents is indicated. The invention
also relates to a method for screening for expression of
cellular markers, secreted factors or tumor antigens by
cells for determining the disease state of the cells and
for monitoring the potential efficacy of treatment agents.

Introduction

All active agents including chemotherapeutic
active agents are subjected to rigorous testing as to
efficacy and safety prior to approval for medical use in
the United States. Methods of assessing efficacy have
included elaborate investigations of large populations in
double blind studies as to a given treatment method and/or
active agent, with concomitant statistical interpretation
of the resulting data, but these conclusions are inevitably
generalized as to patient populations taken as a whole. In
many pharmaceutical disciplines and particularly in the
area of chemotherapy, however, the results of individual
patient therapy may not comport with generalized data--to
the detriment of the individual patient. The need has been
long recognized for a method of assessing the therapeutic
potential of active agents, including but not limited to
chemotherapeutic agents, for their efficacy as to a given
individual patient, prior to the treatment of that patient.
Prior art assays already exist which expose
malignant tissue of various types to a plurality of active
agents, for the purpose of assessing the best choice for

therapeutic administration. For example, in Kruczynski, A., et al., "Evidence of a direct relationship between the increase in the in vitro passage number of human non-small-cell-lung cancer primocultures and their chemosensitivity," _Anticancer Research_, vol. 13, no. 2, pp. 507-513 (1993), chemosensitivity of non-small-cell-lung cancers was investigated in _in vivo_ grafts, in _in vitro_ primocultures and in commercially available long-term cancer cell lines. The increase in chemosensitivity was documented and correlated with morphological changes in the cells in question. Sometimes animal model malignant cells and/or established cell cultures are tested with prospective therapy agents, see for example Arnold, J.T., "Evaluation of chemopreventive agents in different mechanistic classes using a rat tracheal epithelial cell culture transformation assay," _Cancer Res._, vol. 55, no. 3, pp. 537-543 (1995).

In vitro prior art techniques present the further shortcoming that assayed cells do not necessarily express the cellular markers they would express _in vivo_. This is regrettable because the determination of expression of certain secreted or cellular markers, secreted factors or tumor antigens or lack thereof can be useful for both identification and therapeutic purposes. For instance, members of the fibrinolytic system such as urokinase-type plasminogen activator (u-PA) and plasminogen activator inhibitors type 1 (PAI-1) are up-regulated in malignant brain tumors. See, e.g., Jasti S. Rao, et al., "The Fibrinolytic System in Human Brain Tumors: Association with Pathophysiological Conditions of Malignant Brain Tumors," Advances in Neuro-Oncology II, Kornblith PL, Walker MD (eds) Futura 1997. Other secreted factors such as α-fetoprotein, carcinoembryonic antigen and transforming growth factors α and β have been found to be indicative of various cancers and/or cancer progression (see also, Singhal et al., "Elevated Plasma Osteopontin in Metastatic Breast Cancer Associated with Increased Tumor Burden and Decreased Survival," Clinical Cancer Research, Vol. 3, 605-

611, April 1997; Kohno et al., "Comparative Studies of CAM 123-6 and Carcinoembryonic Antigen for the Serological Detection of Pulmonary Adenocarcinoma," Cancer Detection and Prevention, 21(2): 124-128 (1997)). These examples are but a few of the many factors that may be used to identify diseased cells.

Often the diseased cells express a cellular marker that is indicative of a certain disease state or lack thereof. However, one aspect of the culture techniques of the present invention is that the cultured diseased cells do not necessarily have to be the cells expressing the factor to be assayed. One question that inevitably arises when considering whether a serum marker is indicative of a particular cancer cell is, which cells produce the marker, the cell or the tissue in which the cancer cells grow? See e.g. Singhal et al., p 610. By co-culturing the cancerous tissue within a multicellular particulate of its originating tissue, the cells (both the diseased cells or the surrounding cells) are better able to retain their production of characteristic markers.

When actual patient cells are used to form _in vitro_ assays focused on individual patients, in typical prior art processes the cells are harvested (biopsied) and trypsinized (connective tissue digested with the enzyme trypsin) to yield a cell suspension suitable for conversion to the desired tissue culture form. The _in vitro_ tissue culture cell collections which result from these techniques are generally plagued by their inability accurately to imitate the chemosensitivity of the original tumor or other cell biopsy. These collections often do not express cellular markers in the same manner that they would _in vivo_. Standard cloning and tissue culture techniques are moreover excessively complicated and expensive for use in a patient-by-patient assay setting. A need thus remains for a technique of tissue culture preparation which provides cell cultures, for drug screening purposes, in which after simple preparation the cell cultures react in

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a manner equivalent to their _in vivo_ reactivity, to enable drug or chemotherapeutic agent screening as to a particular patient for whom such screening is indicated. A need also remains for a technique of tissue culture preparation which provides cell cultures for screening for expressed markers or factors where the cultured cells express the markers or factors in a manner indicative of their _in vivo_ expression of the same.

Summary of the Invention

In order to meet these needs, the present invention is an improved system for screening a multiple of candidate therapeutic or chemotherapeutic agents for efficacy as to a specific patient, in which a tissue sample from the patient is harvested, cultured and separately exposed to a plurality of treatments and/or therapeutic agents for the purpose of objectively identifying the best treatment for the cultured cells obtained from the patient. The culture techniques of the present invention also result in a monolayer of cells that express cellular markers, secreted factors and tumor antigens in a manner representative of their expression _in vivo_. Specific method innovations such as tissue sample preparation techniques render this method practically as well as theoretically useful. One particularly important tissue sample preparation technique is the initial preparation of cohesive multicellular particulates of the tissue sample, rather than enzymatically dissociated cell suspensions or preparations, for initial tissue culture monolayer preparation. With respect to the culturing of malignant cells, for example, it is believed (without any intention of being bound by the theory) that by maintaining the malignant cells within a multicellular particulate of the originating tissue, growth of the malignant cells themselves is facilitated versus the overgrowth of fibroblasts or other cells which tends to occur when suspended tumor cells are grown in culture. Practical

monolayers of cells may thus be formed to enable meaningful screening of a plurality of treatments and/or agents as well as meaningful identification of cellular markers. In the drug assays, growth of cells is monitored to ascertain the time to initiate the assay and to determine the growth rate of the cultured cells; sequence and timing of drug addition is also monitored and optimized. By subjecting uniform samples of cells to a wide variety of active agents (and concentrations thereof), the most efficacious agent can be determined. For assays concerning cancer treatment, a two-stage evaluation is contemplated in which both acute cytotoxic and longer term inhibitory effects of a given anti-cancer agent are investigated.

With regard to the identification of expressed cellular markers, secreted factors or tumor antigens, with the initial culturing of the multicellular particulates it is believed (without any intention of being bound by the theory) that because the cells are grown under conditions closer to those found _in vivo_, the cells express their cellular markers, secreted factors and tumor antigens in a manner more closely resembling their expression _in vivo_. By assaying the culture media obtained from growing a monolayer according to the inventive method or by histochemically and/or immunohistochemically assaying the cells grown under such conditions, a more accurate profile of the cellular markers or factors is obtained.

Detailed Description of the Invention

The present invention is a system for screening a multiple of candidate therapeutic or chemotherapeutic agents for efficacy as to a specific patient, in which a tissue sample from the patient is harvested and separately exposed to a plurality of treatments and/or therapeutic agents for the purpose of objectively identifying the best treatment or agent. Specific method innovations such as tissue sample preparation techniques render this method practically as well as theoretically useful. One particularly important tissue sample preparation technique

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is the initial preparation of cohesive multicellular particulates (explants) of the tissue sample, rather than enzymatically dissociated cell suspensions or preparations, for initial tissue culture monolayer preparation. Cell growth, and sequence and timing of drug addition, are monitored and optimized.

An important application of the present invention is the screening of chemotherapeutic agents and other antineoplastic therapies against tissue culture preparations of malignant cells from the patients from whom malignant samples are biopsied. Related anti-cancer therapies which can be screened using the inventive system are both radiation therapy and agents which enhance the cytotoxicity of radiation, as well as immunotherapeutic anti-cancer agents. Screening procedures for treatments or therapeutic agents for nonmalignant syndromes are also embraced within this invention, however, and include without limitation agents which combat hyper proliferative syndromes, such as psoriasis, or wound healing agents. Nor is the present efficacy assay limited only to the screening of active agents which speed up (healing) or slow down (anti-cancer, anti-hyper proliferative) cell growth because agents intended to enhance or to subdue intracellular biochemical functions may be tested in the present tissue culture system also. For example, the formation or blocking of enzymes, neurotransmitters and other biochemicals may be screened with the present assay methods prior to treatment of the patient.

When the patient is to be treated for the presence of tumor, in the preferred embodiment of the present invention a tumor biopsy of >100 mg of non-necrotic, non-contaminated tissue is harvested from the patient by any suitable biopsy or surgical procedure known in the art. Biopsy sample preparation generally proceeds as follows under a Laminar Flow Hood which should be turned on at least 20 minutes before use. Reagent grade ethanol is used to wipe down the surface of the hood prior to

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beginning the sample preparation. The tumor is then removed, under sterile conditions, from the shipping container and is minced with sterile scissors. If the specimen arrives already minced, the individual tumor pieces should be divided into four groups. Using sterile forceps, each undivided tissue quarter is then placed in 3 ml sterile growth medium (Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin) and systematically minced by using two sterile scalpels in a scissor-like motion, or mechanically equivalent manual or automated opposing incisor blades. This cross-cutting motion is important because the technique creates smooth cut edges on the resulting tumor multicellular particulates. Preferably but not necessarily, the tumor particulates each measure 1 mm^3. After each tumor quarter has been minced, the particles are plated in culture flasks using sterile pasteur pipettes (9 explants per to-25 or 20 particulates per to-75 flask). Each flask is then labeled with the patient's code, the date of explanation and any other distinguishing data. The explants should be evenly distributed across the bottom surface of the flask, with initial inverted incubation in a 37° C. incubator for 5-10 minutes, followed by addition of about 5-10 ml sterile growth medium and further incubation in the normal, non-inverted position. Flasks are placed in a 35° C, non-CO_2 incubator. Flasks should be checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the explants will foster growth of cells into a monolayer. With respect to the culturing of malignant cells, it is believed (without any intention of being bound by the theory) that by maintaining the malignant cells within a multicellular particulate of the originating tissue, growth of the malignant cells themselves is facilitated versus the overgrowth of fibroblasts (or other unwanted cells) which tends to occur when suspended tumor cells are grown in culture.

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The use of the above procedure to form a cell monolayer culture maximizes the growth of malignant cells from the tissue sample, and thus optimizes ensuing tissue culture assay of chemotherapeutic action of various agents to be tested. Enhanced growth of actual malignant cells is only one aspect of the present invention, however; another important feature is the growth rate monitoring system used to oversee growth of the monolayer once formed. Once a primary culture and its derived secondary monolayer tissue culture has been initiated, the growth of the cells is monitored to ascertain the time to initiate the chemotherapy assay and to determine the growth rate of the cultured cells.

Monitoring of the growth of cells is conducted by counting the cells in the monolayer on a periodic basis, without killing or staining the cells and without removing any cells from the culture flask. The counting may be done visually or by automated methods, either with or without the use of estimating techniques known in the art (counting in a representative area of a grid multiplied by number of grid areas, for example). Data from periodic counting is then used to determine growth rates which may or may not be considered parallel to growth rates of the same cells <u>in</u> <u>vivo</u> in the patient. If growth rate cycles can be documented, for example, then dosing of certain active agents can be customized for the patient. The same growth rate can be used to evaluate radiation treatment periodicity, as well. It should be noted that with the growth rate determinations conducted while the monolayers grow in their flasks, the present method requires no hemocytometry, flow cytometry or use of microscope slides and staining, with all their concomitant labor and cost.

Protocols for monolayer growth rate generally use a phase-contrast inverted microscope to examine culture flasks incubated in a 37° C. (5% CO_2) incubator. When the flask is placed under the phase-contrast inverted microscope, ten fields (areas on a grid inherent to the

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flask) are examined using the 10x objective, with the proviso that the ten fields should be non-contiguous, or significantly removed from one another, so that the ten fields are a representative sampling of the whole flask. Percentage cell occupancy for each field examined is noted, and averaging of these percentages then provides an estimate of overall percent confluency in the cell culture. When patient samples have been divided between two or among three or more flasks, an average cell count for the total patient sample should be calculated. The calculated average percent confluency should be entered into a process log to enable compilation of data--and plotting of growth curves--over time. Monolayer cultures may be photographed to document cell morphology and culture growth patterns. The applicable formula is:

Percent confluency = $\dfrac{\text{estimate of the area occupied by cells}}{\text{total area in an observed field.}}$

As an example, therefore, if the estimate of area occupied by the cells is 30% and the total area of the field is 100%, percent confluency is 30/100, or 30.

Adaptation of the above protocol for non-tumor cells is straightforward and generally constitutes an equivalent procedure.

Active agent screening using the cultured cells does not proceed in the initial incubation flask, but generally proceeds using plates such as microtiter plates. The performance of the chemosensitivity assay used for screening purposes depends on the ability to deliver a reproducible cell number to each row in a plate and/or a series of plates, as well as the ability to achieve an even distribution of cells throughout a given well. The following procedure assures that cells are reproducibly transferred from flask to microtiter plates, and cells are evenly distributed across the surface of each well.

The first step in preparing the microtiter plates is, of course, preparing and monitoring the monolayer as described above. The following protocol is exemplary and

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susceptible of variation as will be apparent to one skilled in the art. Cells are removed from the culture flask and a cell pellet is prepared by centrifugation. The cell pellet derived from the monolayer is then suspended in 5 ml of the growth medium and mixed in a conical tube with a vortex for 6 to 10 seconds. The tube is then rocked back and forth 10 times. A 36 μl droplet from the center of the conical tube is pipetted onto one well of a 96 well plate. A fresh pipette is then used to pipette a 36 μl aliquot of trypan blue solution, which is added to the same well, and the two droplets are mixed with repeated pipette aspiration. The resulting admixture is then divided between two hemocytometer chambers for examination using a standard light microscope. Cells are counted in two out of four hemocytometer quadrants, under 10x magnification. Only those cells which have not taken up the trypan blue dye are counted. This process is repeated for the second counting chamber. An average cell count per chamber is thus determined. Using means known in the art, the quadrant count values are checked, logged, multiplied by 10^4 to give cells/ml, and the total amount of fluid (growth medium) necessary to suspend remaining cell aliquots is calculated accordingly.

After the desired concentration of cells in medium has been determined, additional cell aliquots from the monolayer are suspended in growth medium via vortex and rocking and loaded into a Terasaki dispenser known in the art. Aliquots of the prepared cell suspension are delivered into the microtiter plates using Terasaki dispenser techniques known in the art. A plurality of plates may be prepared from a single cell suspension as needed. Plates are then wrapped in sterile wet cotton gauze and incubated in an incubator box by means known in the art.

After the microtiter plates have been prepared, exposure of the cells therein to active agent is conducted according to the following exemplary protocol. During this portion of the inventive assay, the appropriate amount of specific active agent is transferred into the microtiter plates prepared as described above. A general protocol, which may be adapted, follows. Each microtiter plate is unwrapped from its wet cotton gauze sponge and microscopically examined for cell adhesion. Control solution is dispensed into delineated rows of wells within the grid in the microtiter plate, and appropriate aliquots of active agent to be tested are added to the remaining wells in the remaining rows. Ordinarily, sequentially increasing concentrations of the active agent being tested are administered into progressively higher numbered rows in the plate. The plates are then rewrapped in their gauze and incubated in an incubator box at 37° C. under 5% CO_2. After a predefined exposure time, the plates are unwrapped, blotted with sterile gauze to remove the agent, washed with Hank's Balance Salt Solution, flooded with growth medium, and replaced in the incubator in an incubator box for a predefined time period, after which the plates may be fixed and stained for evaluation.

Fixing and staining may be conducted according to a number of suitable procedures; the following is representative. After removal of the plates from the incubator box, culture medium is poured off and the plates are flooded with Hank's Balance Salt Solution. After repeated flooding (with agitation each time) the plates are then flooded with reagent grade ethanol for 2-5 minutes. The ethanol is then poured off. Staining is accomplished with approximately 5 ml of Giemsa Stain per plate, although volume is not critical and flooding is the goal. Giemsa stain should be left in place 5 min. ± 30 seconds as timing influences staining intensity. The Giemsa stain is then poured off and the plates are dipped three times in cold tap water in a beaker. The plates are then inverted,

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shaken vigorously, and air dried overnight (with plate lids off) on a rack on a laboratory bench. Cells per well are then counted manually or by automated and/or computerized means, to derive data regarding chemosensitivity of cells at various concentrations of exposure. One particularly useful computer operating environment for counting cells is the commercially available OPTIMATE compiler, which is designed to permit an optical counting function well suited to computerized cell counting procedures and subsequent calculations.

The above procedures do not change appreciably when cell growth promoters are assayed rather than cell arresting agents such as chemotherapeutic agents. The present assay allows cell death or cell growth to be monitored with equal ease. In any case, optimization of use of the present system will involve the comparative testing of a variety of candidate active agents for selection of the best candidate for patient treatment based upon the in vitro results. One particularly advantageous embodiment of the above described invention comprises a two-stage assay for cytotoxicity followed by evaluation of longer-term inhibitory effect. Chemotherapeutic agents may thus be evaluated separately for both their direct chemotherapeutic effect as well as for their longer duration efficacy.

Identification of one or more active agents or chemotherapeutic agents is peripheral to the present invention, which is intended for the efficacy screening of any or all of them as to a given patient. Literally any active agent may be screened according to the present invention; listing exemplary active agents is thus omitted here.

The essence of the invention thus includes the important feature of the simplicity of the present system-- cohesive multicellular particulates of the patient tissue to be tested are used to form cell monolayers; growth of those monolayers is monitored for accurate prediction of

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correlating growth of the same cells _in vivo_; and differing concentrations of a number of active agents may be tested for the purpose of determining not only the most appropriate agent but the most appropriate concentration of that agent for actual patient exposure (according to the calculated cell growth rates). It is also important to note, in the context of the invention, that the present system allows _in vitro_ tests to be conducted in suspensions of tissue culture monolayers grown in nutrient medium under fast conditions (a matter of weeks), rather than with single cell progeny produced by dilution cloning over long periods of time. In some cases, the present invention is a two stage assay for both cytotoxicity and the longer-term growth inhibitory.

Another important aspect of the present invention is to provide a system for screening specific tissue samples from individual patients for expressed cellular markers, secreted factors or antigens, including tumor antigens, characteristic of the tissue sample. A tissue sample from a patient is harvested and grown in a monolayer culture as described above. Culture medium in which the primary monolayer culture or subcultures thereof can then be assayed for the presence or absence of certain factors, such as secreted tumor antigens like PAI-1, u-PA or carcinoembryonic antigen. These factors may be detected through use of standard assays such as radioimmunoassay (RIA) or enzyme-linked immunosorbent assay (ELISA) although the many other assays known to those skilled in the art may be used to detect and/or quantify the soluble factors. The cell cultures grown in this manner may also be assayed histochemically and or immunohistochemically for identification or quantification of cellular or membrane-bound markers. By screening tissue samples in this manner for production of such factors, markers or antigens, the cultured cells may be further identified, aiding the physician in treatment strategies and as a prognosis indicator. Furthermore, by combining the use of the

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culture technique with assaying for such markers, factors and antigens, a treatment strategy for a disease state may be optimized and treatment progression may be monitored.

Lastly, immunological markers may be monitored in applications requiring up- or down- regulation of such markers (i.e., Major histocompatibility complex molecules). This aspect of the present invention can be especially useful in transplantation applications where, for instance, through chemical or biological means rejection of transplanted cells is sought to be avoided by down-regulation of the various transplantation antigens present on the cells to be transplanted. The present invention would be especially useful in monitoring such immunoregulation.

Example 1: Radiation Therapy

Separate 50 mg samples from residual tissue from specimens of three human glioblastomas and one human ovarian carcinoma were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 16 groups was charged to a separate labeled culture flask containing the above-described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO_2 incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the 16 flasks. Each cell pellet was then suspended in 5 ml of the above-

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described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well of a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification--only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the 16 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours later, the cells were irradiated using a Siemens Stabilipan X-ray machine at 250 kVp, 15mA with a dose rate of 75 rad/minute. For each radiation dose from 1Gy to 6Gy, cell number per well was monitored as a function of time through five days post-irradiation.

Cell number relative to controls was determined and survival curves were fit to the data. The rate of decrease in survival as a function of time was proportional to dose. A differential radiation response among the four cell lines was observed.

Separate 50 mg samples from residual tissue from specimens of a human brain tumor, renal carcinoma, and breast carcinoma were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 12 groups was charged to a separate labeled culture flask containing the above-described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO$_2$ incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the twelve flasks. Each cell pellet was then suspended in 5 ml of the above-described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification--only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

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Accommodating the above calculations, additional cell aliquots from the 12 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating, Activated Natural Killer (ANK) cells were delivered into a row of six wells by means of a micropipette. In each microtiter plate three rows of six wells each served as controls. The effector (ANK cells): target cell (tumor cells) ratio varied from 2.5:1 to 20:1. The ANK cells were exposed to the target cells for four hours. Subsequently, the wells were washed with Hanks Balanced Salt Solution and the number of ANK cells remaining in the wells was observed with a phase contrast microscope. This process was repeated until no ANK cells remained in the wells (usually 3 washes). Following removal of the ANK cells, the tumor cells were incubated in the wells for another 24 hours.

Cell number relative to control was determined. For the three tumor types increasing the effector:target cell ratio from 2.5:1 to 20:1 resulted in an increase in the number of tumor cells killed by the ANK cells.

Example 3: Gene Therapy/Antisense Oligonucleotides

A 50 mg sample from a residual human mesothelioma was minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. The 50 mg sample was minced and was divided into four groups of particulates and each of four groups was charged to a separate labeled culture flask containing the above-

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described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO_2 incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the four flasks. Each cell pellet was then suspended in 5 ml of the above-described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well of a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification--only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the four monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating, antisense oligonucleotide for the urokinase-type plasminogen activator receptor (uPAR) was delivered to wells in the microtiter plate. Proteolysis of plasminogen to plasmin by urokinase-type plasminogen activator has been implicated in the processes of tumor cell proliferation and invasion. The concentrations of the uPAR antisense oligonucleotide were 1, 10 and 100 micromolar. uPAR sense and missense oligonucleotides at the concentrations of 1, 10 and 100 micromolar served as controls. The tumor cells were exposed to the oligonucleotides for 24 hours and then the agents were removed. The cells were allowed to incubate for another 72 hours so that inhibition of cell proliferation could be observed.

Cell number relative to control was then determined. Antisense oligonucleotides to uPAR suppressed the proliferative activity of the tumor cells in a concentration dependent manner.

Example 4: Combination Chemotherapy

Separate 50 mg samples from residual tissue from specimens from four human ovarian tumors were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 16 groups was charged to a separate labeled culture flask containing the above-described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO$_2$ incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the 16 flasks. Each cell pellet was then suspended in 5 ml of the above-described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification--only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the 16 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating, the chemotherapeutic agent taxol was applied to the wells in the microtiter plates. The first three treatment rows in the plates (Rows 2, 3, and 4) were designed to have escalating taxol doses (1.0, 5.0, and 25 μM) with a fixed carboplatin dose (200 μM). The last three treatment rows in the plates (Rows 6, 7, and 9) were designed to have a fixed taxol dose (5 μM) with an escalating carboplatin dose (50, 200, and 1000 μM). Rows 5 and 9 served as a control.

The taxol exposure time was two hours. Twenty-four hours later, the cells in the wells were exposed to carboplatin for two hours. The tumor cells in the wells were then incubated for another 48 hours.

5   Cell number relative to control was determined. For the cells from the four tumor specimens a dose response relationship   was   observed   for   both   the   escalating taxol/fixed   carboplatin   and   fixed   taxol/escalating carboplatin treatment schema.

10   Example 5: Hormonal Therapy

          Separate 50 mg samples from residual tissue from specimens from four human breast tumors were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about

15   .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 16 groups was charged to a separate labeled culture

20   flask containing the above-described medium.   Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO_2 incubator. Flasks were checked daily for growth and contamination. Over a period

25   of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

          Enough   cells   were   then   removed   from   the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the 16 flasks. Each

30   cell pellet was then suspended in 5 ml of the above- described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times.   A 36 microliter droplet from the center of each tube was then pipetted into one well of a

35   96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was

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then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification--only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the 16 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating, the antiestrogenic compound tamoxifen was delivered to wells in the microtiter plates. A stock solution of tamoxifen was initially prepared by dissolving 1.5 mg of tamoxifen powder in 1 ml of absolute ethanol and then adding 9 ml of growth medium. This stock solution was then used to make tamoxifen solutions in the concentration range of 10 nM to 20 μM. Six doses of tamoxifen were used for cells from each of the four breast tumor specimens. An ethanol solution at a concentration equivalent to that at the highest tamoxifen concentration served as a control. The tumor cells were exposed to tamoxifen for 24 hours and then the agent was removed. The cells were allowed to incubate for another 72 hours so that inhibition of cell proliferation could be observed.

Cell number relative to control was then determined. There was no effect observed when the ethanol-only control wells were compared to the growth medium-only control wells. The cells of two of the four

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breast specimens tested showed an inhibition of cell proliferation by tamoxifen exposure. These responses occurred in the mid to high tamoxifen concentration ranges.

Example 6: Differentiating Agent Therapy
("Biological Response Modification")

Separate 50 mg samples from residual tissue from specimens from four human breast tumors were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 16 groups was charged to a separate labeled culture flask containing the above-described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO_2 incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the 16 flasks. Each cell pellet was then suspended in 5 ml of the above-described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well of a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification only those cells which had not taken up the trypan blue dye were counted. This process was

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repeated for the second counting chamber. An average cell count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the 16 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating the differentiating agent retinoic acid was delivered to wells in the microtiter plates. A stock solution of retinoic acid was initially prepared by dissolving retinoic acid powder in 1 ml of dimethyl sulfoxide (DMSO) and then adding 9 ml of growth medium. This stock solution was then used to make retinoic acid solutions in the concentration range of 0.1 to 1.0 mM. Six doses of retinoic acid were used for cells from each of the four breast tumor specimens. A DMSO solution at a concentration equivalent to that at the highest retinoic acid concentration served as a control. The tumor cells were exposed to retinoic acid for 24 hours and then the agent was removed. The cells were allowed to incubate for another 72 hours so that inhibition of cell proliferation could be observed.

Cell number relative to control was then determined. There was no effect observed when the DMSO-only control wells were compared to the growth medium-only control wells. The cells of three of the four breast specimens tested showed an inhibition of cell proliferation by retinoic acid exposure. These responses occurred in the mid to high retinoic acid concentration ranges.

Separate 50 mg samples from residual tissue from specimens from two human brain tumors and two human ovarian tumors were minced in medium with sterile scissors to a particle size of roughly 1 mm^3 and with a particle size distribution between about .25 and about 1.5 mm^3. The medium was Standard F-10 medium containing 17% calf serum and a standard amount of Penicillin and Streptomycin. Each 50 mg sample was minced and was divided into four groups of particulates and each of 16 groups was charged to a separate labeled culture flask containing the above-described medium. Visual confirmation was made that the particulates were evenly distributed along the bottom of each flask and the flasks were placed in a 35° C, non-CO$_2$ incubator. Flasks were checked daily for growth and contamination. Over a period of a few weeks, with weekly removal and replacement of 5 ml of growth medium, the particulates grew into monolayers.

Enough cells were then removed from the monolayers grown in the flasks for centrifugation into standard size cell pellets for each of the 16 flasks. Each cell pellet was then suspended in 5 ml of the above-described medium and was mixed in a conical tube with a vortex for 6 to 10 seconds, followed by manual rocking back and forth 10 times. A 36 microliter droplet from the center of each tube was then pipetted into one well of a 96-well microtiter plate together with an equal amount of trypan blue, plus stirring. The resulting admixture was then divided between two hemocytometer quadrants for examination using a standard light microscope. Cells were counted in two out of four hemocytometer quadrants, under 10X magnification only those cells which had not taken up the trypan blue dye were counted. This process was repeated for the second counting chamber. An average cell

count per chamber was calculated and by means known in the art the optimum concentration of cells in the medium was determined.

Accommodating the above calculations, additional cell aliquots from the 16 monolayers were separately suspended in growth medium via vortex and rocking and were loaded into a Terasaki dispenser adapted to a 60-well plate. Aliquots of the prepared cell suspension were delivered into the microtiter plates using Terasaki dispenser techniques known in the art. Cells were plated into 60-well microtiter plates at a concentration of 100 cells per well.

Twenty-four (24) hours post-plating, cells in the microtiter plate wells were exposed to the chemotherapeutic agent taxol. One set of plates was designed to have escalating taxol doses with (0.5-25.0 μM) with a fixed radiation dose (2Gy). A second set of plates was designed to have a fixed taxol dose (5 μM) with an escalating radiation dose (1Gy-6Gy). The cells in the plates were irradiated using a Siemans Stabilipan X-ray machine operating at 250 kVp, 15 mA with a dose rate of 75 rad/minute.

For each of the two treatment schema, cell number per well was monitored as a function of time through 5 days post-treatment. Cell number relative to controls was determined and survival curves were fit. A differential response among the cells from the four tumor specimens was observed. Both additive and synergistic cell killing was noted.

Although the present invention has been described with respect to specific materials and methods above, the invention is only to be considered limited insofar as is set forth in the accompanying claims.

I claim:

1.   A method for assessing chemosensitivity of patient cells comprising the steps of:

a)   harvesting a specimen of a patient's tissue, cells ascites, or effusion fluid;

b)   separating said specimen into multicellular particulates;

c)   growing a tissue culture monolayer from said cohesive multicellular particulates;

d)   inoculating cells from said monolayer into a plurality of segregated sites; and

e)   treating said plurality of sites with at least one treating means, followed by assessment of sensitivity of the cells in said site to said at least one treating means.

2.   The method according to claim 1 wherein step a) further comprises the step of

a)   preparing a specimen which was harvested from a sample of patient tumor tissue.

3.   The method according to claim 1 wherein said plurality of segregated sites further comprises a plate containing a plurality of wells therein.

4.   The method according to claim 1 wherein step e) further comprises the step of:

e)   treating said plurality of sites with a plurality of active agents at varied concentrations, followed by assessment of optimal chemosensitivity with respect to a single active agent at a single concentration.

5. The method according to claim 1 wherein said treating means further comprises:

treating said plurality of sites with a plurality of active agents over a length of time adequate to permit assessment of both initial cytotoxic effect and longer-term inhibitory effect of at least one of said plurality of active agents.

6. The method according to claim 1 wherein the sensitivity assayed according to step e) is anti-cancer sensitivity.

7. The method according to claim 1 wherein step d) is accomplished using a Terasaki dispenser.

8. The method according to claim 1 wherein the cells in step d) are prepared in suspension prior to inoculation into a plurality of wells in a culture plate.

9. The method according to claim 1 wherein said treating means is a chemotherapeutic agent.

10. The method according to claim 1 wherein said active agent is a wound healing agent.

11. The method according to claim 1 wherein said treating means is a radiation therapy and/or a radiation therapy sensitizing or ameliorating agent.

12. The method according to claim 1 where said treating means is an immunotherapeutic agent.

13. The method according to claim 1 wherein the step of assessment of sensitivity includes monitoring culture medium in which the monolayer is grown for production of soluble factors indicative of a disease state or lack thereof.

14. The method according to claim 1 wherein the step of assessment of sensitivity includes histochemical or immunohistochemical detection of cellular markers.

15. A method for identifying chemosensitivity of patient cells comprising the steps of:

a) harvesting a specimen of a patient's tissue, cells ascites, or effusion fluid;

b) separating said specimen into multicellular particulates;

c) growing a tissue culture monolayer from said cohesive multicellular particulates; and

d) immunohistochemically staining said cells to identify one or more cellular factors.

16. A method for identifying secreted cellular antigens produced by patient cells comprising the steps of:

a) harvesting a specimen of a patient's tissue, cells ascites, or effusion fluid;

b) separating said specimen into multicellular particulates;

c) growing a tissue culture monolayer in culture medium from said cohesive multicellular particulates; and

d) assaying said culture medium for secreted factors.

17. The method according to claim 1 wherein said treating means is a gene therapy agent.

18. The method according to claim 17 wherein said gene therapy agent is an antisense oligonucleotide.

19. The method according to claim 1 wherein said treating means is a combination of two or more therapeutic agents.

20.   The method according to claim 1 wherein said treating means is a hormone.

21.   The method according to claim 1 wherein said treating means is a biological response modifier.

Abstract of the Disclosure

      An improved system for screening a multiple of candidate therapeutic or chemotherapeutic agents for efficacy as to a specific patient, in which a tissue sample from the patient is harvested, cultured and separately exposed to a plurality of treatments and/or therapeutic agents for the purpose of objectively identifying. One particularly important tissue sample preparation technique is the initial preparation of cohesive multicellular particulates of the tissue sample. For assays concerning cancer treatment, a two-stage evaluation is contemplated in which both acute cytotoxic and longer term inhibitory effect of a given anti-cancer agent are investigated. The tissue sample technique of the present invention is also useful in assaying expression and/or secretion of various markers, factors or antigens present on or produced by the cultured cells for diagnostic purposes and for using such expression to monitor the applicability of certain candidate therapeutic or chemotherapeutic agents and the progress of treatment with those agents.

DECLARATION AND POWER OF ATTORNEY

Paul L. Kornblith declares:

I am a citizen of the United States of America and a resident of the City of Pittsburgh, County of Allegheny, Commonwealth of Pennsylvania, whose post-office address is 907 Settler's Ridge Road, Pittsburgh, Pennsylvania 15238.

I verily believe myself to be the original, first and sole inventor of the improvement in "Precise Efficacy Assay Methods For Active Agents Including Chemotherapeutic Agents" described and claimed in U.S. Application Serial No. 09/039,957, filed March 16, 1998.

I have reviewed and understand the contents of the specification, including the claims.

That this application in part discloses and claims subject matter disclosed in my earlier filed pending application, Serial No. 08/679,056, filed July 12, 1996.

That, as to the subject matter of this application which is common to said earlier application, I do not know and do not believe that the same was ever known or used in the United States before my invention thereof; or patented or described in any printed publication in any country before my invention thereof or more than one year prior to said earlier application; or in public use or on sale in the United States more than one year prior to said earlier application.

That said common subject matter has not been patented or made the subject of an inventor's certificate before the date of said earlier application in any country foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months prior to said earlier application.

That no application for patent or inventor's certificate on said invention set forth in said earlier application filed by me or my legal representatives or assignees was filed in any country foreign to the United States.

That, as to the subject matter of this application which is not common to said earlier application, I do not know and do not believe that the same was ever known or used in the United States before my invention thereof; or patented or described in any printed publication in any country before my invention thereof or more than one year prior to the date of this application, or in public use or on sale in the United States more than one year prior to the date of this application.

That said subject matter of this application which is not common to said earlier application has not been patented or made the subject of an inventor's certificate in any country foreign to the United States on an application filed by me or my legal representatives or assigns more than twelve months prior to the date of this application.

That no application for patent or inventor's certificate on said invention first set forth in this application filed by me or my representatives or assigns was filed in any country foreign to the United States.

I acknowledge my duty to disclose information of which I am aware which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a) including matters as occurred between the filing date of my said earlier application and the filing date of this application.

I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

I hereby appoint Barbara E. Johnson, Registration No. 31,198; William H. Logsdon, Registration No. 22,132; Russell D. Orkin, Registration No. 25,363; David C. Hanson, Registration No. 23,024; Richard L. Byrne, Registration No. 28,498; Frederick B. Ziesenheim, Registration No. 19,438; Kent E. Baldauf, Registration No. 25,826; Paul M. Reznick, Registration No. 33,059; John W. McIlvaine, Registration No. 34,219; Michael I. Shamos, Registration No. 30,424; Blynn L. Shideler, Registration No. 35,034; Julie W. Meder, Registration No. 36,216; Lester N. Fortney, Registration No. 38,141; Randall A. Notzen, Registration No. 36,882; Jesse A. Hirshman, Registration No. 40,016; James G. Porcelli, Registration No. 33,757; and Kent E. Baldauf, Jr., Registration No. 36,082, whose post-office address is 700 Koppers Building, 436 Seventh Avenue, Pittsburgh, Pennsylvania 15219-1818, Telephone No. 412-471-8815, my attorneys with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith, to amend the specification, to appeal in case of rejection, as they may deem advisable, to receive the patent when granted and generally to do all matters and things needful in the premises, as fully and to all intents and purposes as I could do.

All correspondence and telephone calls should be addressed to Barbara E. Johnson.

I hereby subscribe my name to the foregoing specification and claims, declaration and power of attorney this _2 2nd_ day of _May_ , 1998.

Paul L. Kornblith
Paul L. Kornblith

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Applicant or Patentee: _Paul L. Kornblith_   Attorney's
Serial or Patent No.: _09/039,957_   Docket No.: _2509-970451_
Filed or Issued: _March 16, 1998_
     Precise Efficacy Assay Methods for Active
For: _Agents Including Chemotherapeutic Agents_

**VERIFIED STATEMENT (DECLARATION) CLAIMING SMALL ENTITY STATUS
(37 CFR 1.9(f) & 1.27(c))--SMALL BUSINESS CONCERN**

I hereby declare that I am

   ___   the owner of the small business concern identified below:
   _X_   an official of the small business concern empowered to act on behalf
        of the concern identified below:
   NAME OF SMALL BUSINESS CONCERN____Precision Therapeutics, Inc.____
   ADDRESS OF SMALL BUSINESS CONCERN_3636 Boulevard of the Allies_
                            Pittsburgh, PA 15213

     I hereby declare that the above identified small business concern qualifies
as a small business concern as defined in 13 CFR 121.12, and reproduced in 37 CFR
1.9(d), for purposes of paying reduced fees to the United States Patent and
Trademark Office, in that the number of employees of the concern, including those
of its affiliates, does not exceed 500 persons. For purposes of this statement,
(1) the number of employees of the business concern is the average over the
previous fiscal year of the concern of the persons employed on a full-time,
part-time or temporary basis during each of the pay periods of the fiscal year,
and (2) concerns are affiliates of each other when either, directly or
indirectly, one concern controls or has the power to control the other, or a
third party or parties controls or has the power to control both.

     I hereby declare that rights under contract or law have been conveyed to and
remain with the small business concern identified above with regard to the
invention, entitled_Precise Efficacy Assay Methods For Active Agents Including
Chemotherapeutic Agents_____ by inventor(s) _Paul L. Kornblith_

described in

   ___   the specification filed herewith.
   _X_   application serial no._09/039,957_____, filed_March 16, 1998_____.
   ___   patent no._____, issued_____.

     If the rights held by the above identified small business concern are not
exclusive, each individual, concern or organization having rights in the
invention is listed below* and no rights to the invention are held by any person,
other than the inventor, who would not qualify as an independent inventor under
37 CFR 1.9(c) if that person made the invention, or by any concern which would
not qualify as a small business concern under 37 CFR 1.9(d), or a nonprofit
organization under 37 CFR 1.9(e). *NOTE: Separate verified statements are
required from each named person, concern or organization having rights to the
invention averring to their status as small entities. (37 CFR 1.27)

NAME_____
ADDRESS_____
       _INDIVIDUAL_____SMALL BUSINESS CONCERN_____NONPROFIT ORGANIZATION

NAME_____
ADDRESS_____
       _INDIVIDUAL_____SMALL BUSINESS CONCERN_____NONPROFIT ORGANIZATION

     I acknowledge the duty to file, in this application or patent, notification
of any change in status resulting in loss of entitlement to small entity status
prior to paying, or at the time of paying, the earliest of the issue fee or any
maintenance fee due after the date on which status as a small entity is no longer
appropriate. (37 CFR 1.28(b))

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application, any patent issuing thereon, or any patent to which this verified statement is directed.
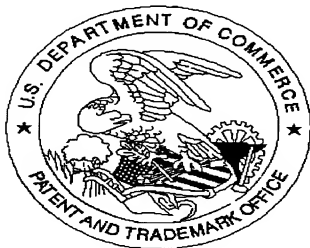
NAME OF PERSON SIGNING_____Paul L. Kornblith_____

TITLE OF PERSON IF OTHER THAN OWNER_President_____

3636 Boulevard of the Allies
ADDRESS OF PERSON SIGNING_____Pittsburgh, PA 15213_____

SIGNATURE____Paul L Kornblith_____ DATE__5/22/98_____

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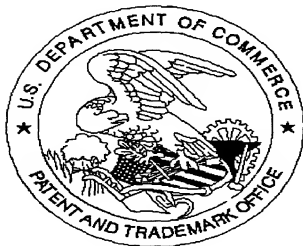
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